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Lessons Learned in Technology Transition

Joseph H. Osborne
ASETSDefense 2011 – New Orleans, LA

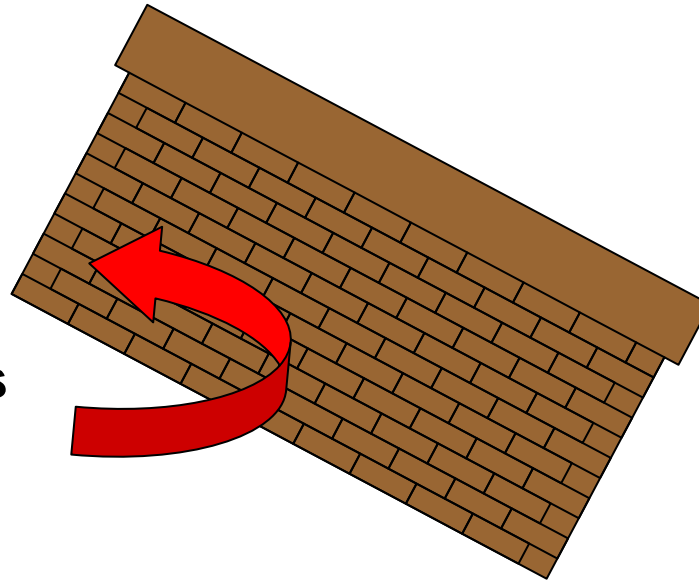
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Transferring Technology through the “valley of death”

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**Developers with
Great technologies**



Production Success

**Developers see opportunity
for applications**

Programs see risk in change

- production cost and schedule
- training, supply, sustainment
- performance liability

→ Developers need to help programs mitigate risk factors ←

Overview

- **Design and production process**
- **Drivers for change**
- **Specification driven processes**
- **Examples of successful transitions**
 - Vapor degreasers
 - Nonchromate anodize
 - Cadmium Alternatives
 - Nonchromate primers
 - Basecoat/clearcoat
- **Conclusions**

Drivers for Change in Industry

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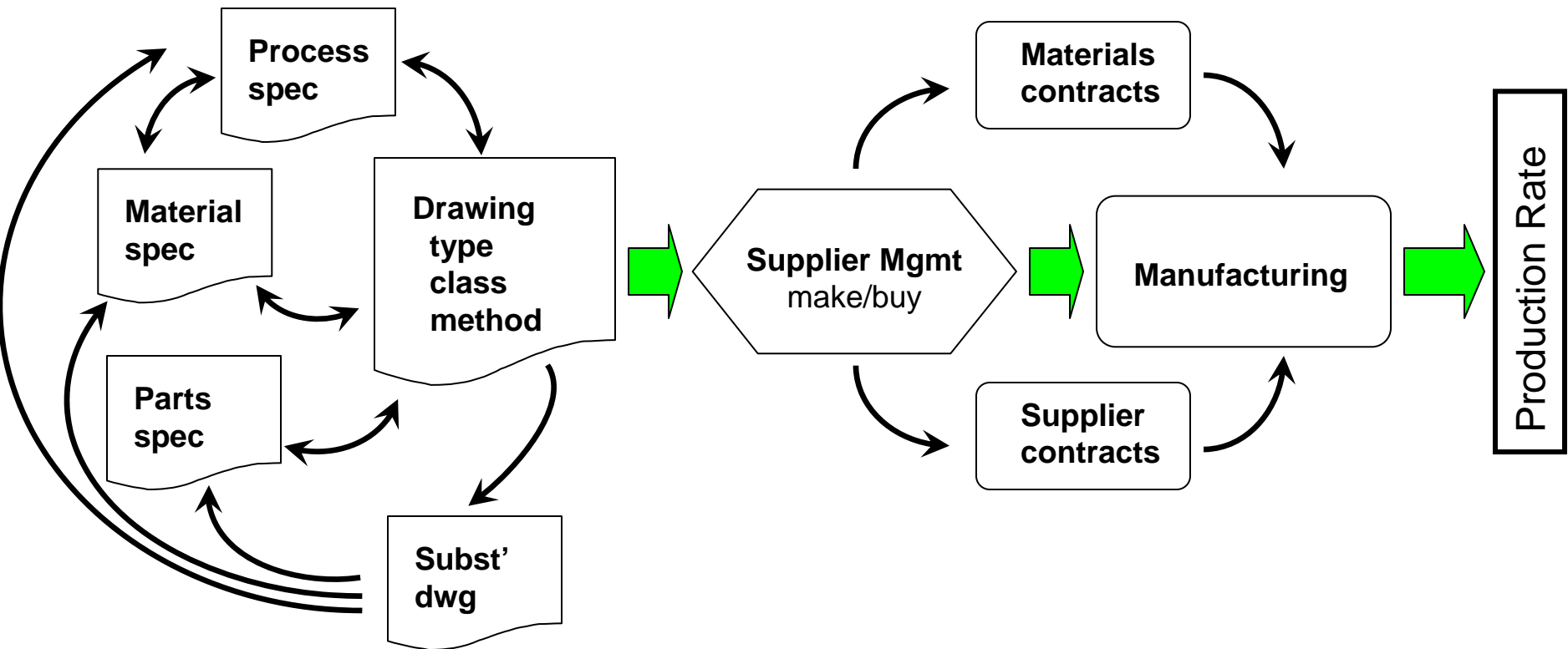
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- **Make products more cost effective (improve “value”)**
 - Lower direct cost, improve schedule, increase reliability, etc.
 - Weight reduction is key for aerospace products
- **Regulatory requirements**
 - Safety equipment, reporting requirements
 - Balance noncompliance costs versus performance risks
 - Balance between cost of compliance and cost of redesign and recertification
- **Environmental regulations**
 - Federal clean air act
 - OSHA and EPA requirements
 - Cadmium, hexavalent chromium, VOC
 - ReaCH



Change in production is difficult

- Multiple elements to drawing controlled parts



- Production processes that are not drawing controlled are sometimes easier to implement

Timing is Important

- **Product cycles have three stages**

- **Design and definition – easiest transition point**

- Drawings are being created/modified
 - Need to be production ready
 - Stable process and materials
 - Adequate supply base / be able to meet rate
 - Well defined performance, production, sustainment processes

- **Transition to production**

- Configuration and dwgs are final
 - Install infrastructure/tanks/tooling/jigs/etc.
 - Establish supply contracts (typically long term)
 - Establish training and support processes

- **Production**

- Execute production plan
 - Changes difficult at this point
 - Require change to dwg, supply chain, configuration mgmt & control, training

Requirements for Successful Transition to Production

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➔ Meet Vehicle Performance Requirements

- Capable Engineering properties
 - Meet performance specifications
- Adaptable Processing characteristics
 - Appropriate for production environment

➔ Availability

- Commercial product – production quantities

➔ Specification coverage

- Technical Order / Military or industry specifications

• What are the “real” performance requirements?

- Current specification limits?
- Equal or better than today’s coating systems?

• Maintain Safety of personnel and airframe/vehicle

A plan for Success for new technologies

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- **“Getting on the spec” is rarely successful**
 - No incentive at engineering level to expend effort to qualify
 - Specs are minimum requirements
 - Primarily used to define and control acquisition
 - Programs need lots of addn'l data to mitigate risk
 - Specs are primarily for procurement, not design
- **Recommendation: solve problem for one part**
 - Requires lots of dialog with designers to identify candidates
 - Process/material called out directly on dwg (“point design”)
 - Need draft mtl and process specs to support production
 - Gain production and in-service experience with the part
 - Success on one part leads to more applications
- **For process changes evaluate effect of change of existing work package**
 - Implementation dependent on a business case analysis

Example: Vapor Degreasers and BSAA

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- **Driver for change:**
 - Clean Air Act banning open top degreasers, TCE, PCE
- **Transitioned most production to emulsion degreasers**
 - Few exceptions: honeycomb core, assemblies
- **Closed loop vapor degreasers**
 - Complicated process equipment
- **Nonchromate anodize (Boric Sulfuric Acid Anodize)**
 - Extensive fatigue, corrosion, and paint adhesion testing
 - Adhesion problems led to adoption of unsealed anodize for fully painted parts
 - Eliminates chromates in sealing process

Cadmium replacements

- **Driver: OSHA, REACH**
- **Ongoing development programs for aerospace**
 - JG-PP projects for bright and LHE Cd alternatives
 - C-17 sponsored development with Dipsol for LHE ZnNi
 - Focus on C-17/AF requirements
 - Boeing development of LHE ZnNi
 - Extensive testing on landing gear, fasteners, components
- **Implementations**
 - Aluminum coatings on components, fasteners, connectors
 - Nickel based coatings on connectors
 - ZnNi on fasteners, some components
 - LHE ZnNi on components, fasteners
- **Balance between cost, performance, and environmental impact**

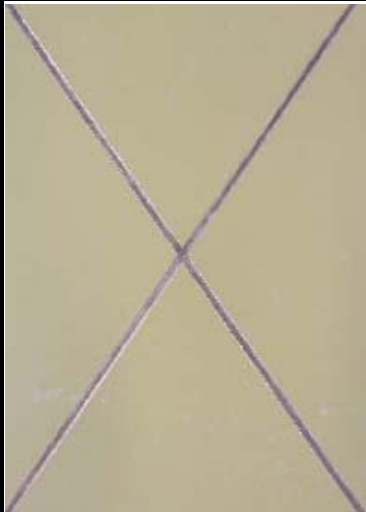


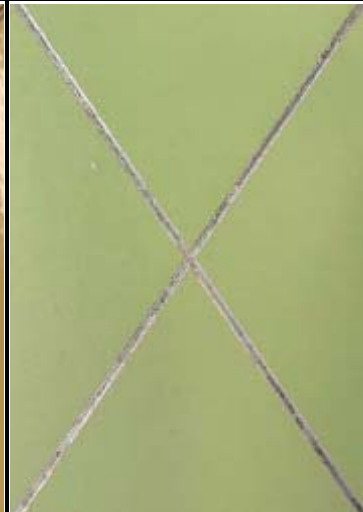

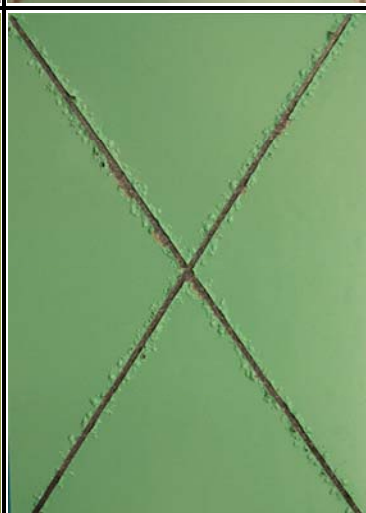

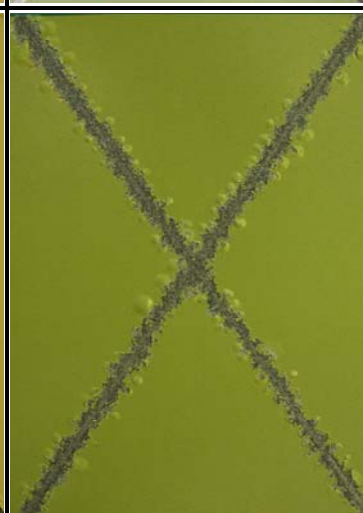
Nonchromate primers

- **Driver: OSHA, EPA**
- **Significant risk for use on critical areas of aircraft**
 - Difficult to inspect and/or repair
 - Flight and/or safety critical
 - Painted once for life of vehicle
- **Customer requirement: equal to or better than CrVI**
 - Evaluation based primarily on ASTM B117 salt fog testing
 - Will require new type or class in specs and drawings
 - Military specs already have “Class N”
 - Drawing change required to implement
 - Starting to evaluate on an applications basis
 - Increases complexity in manufacturing

Interior Primers

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	Chromated Baseline	Non-Cr Primer C	Non-Cr Primer D	Non-Cr Primer E
ASTM B117 Salt Fog				
ASTM G85A2 Acidified Salt Fog				

Paint Improvements

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Continuous product improvement

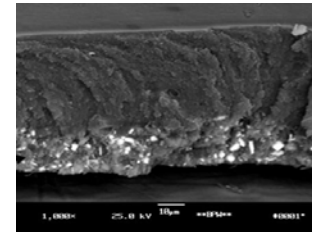
Past Improvements

- Paint Adhesion to Rivets (Rivet Rash)



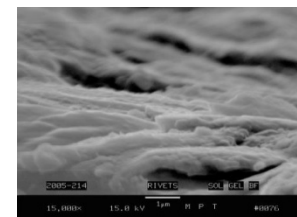
On-Going Efforts

- Non-Chromated Exterior System
Non-chromated conversion coat and primer
- Non-Chrome for other areas
- Chemical topcoat reactivation



Future Advancements

- High durability, efficient topcoat systems (BCCC)



Nonchromate Exterior Decorative Paint

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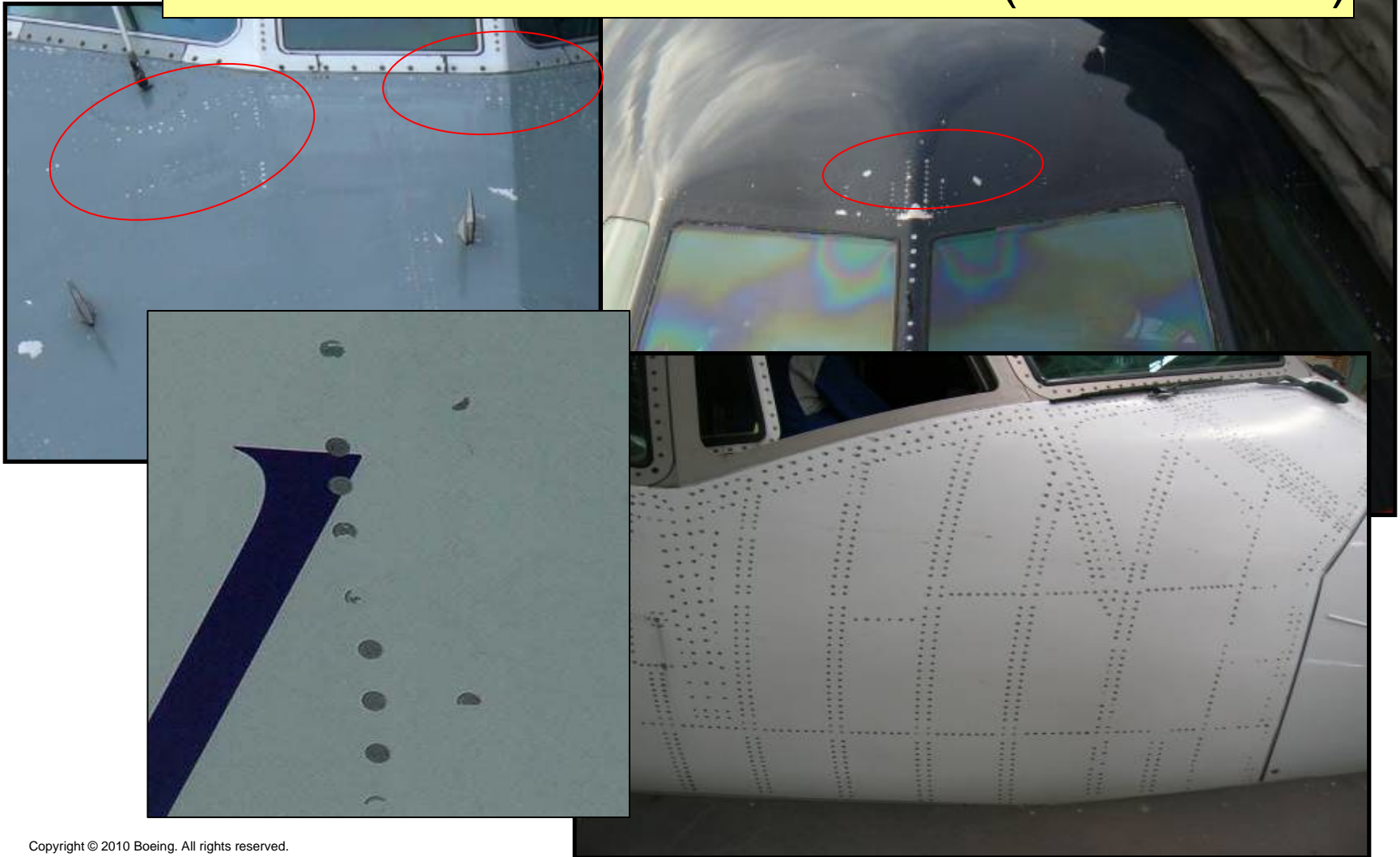
- **Driver: Paint adhesion failure on rivets**
- **Maintained rivet part configuration**
 - added boegel/AC-131 as “finish”
 - Extensive validation of fatigue and NDI compatibility
- **Boegel/AC-131 replaced Alodine 1000 for additional adhesion enhancement**
 - Benefit: reduced Cr(VI), reduced rinse water and flow time
 - Challenge: depainting is more difficult
- **NonCr(VI) primer implemented on all models**
 - Validation of corrosion protection, fluid and topcoat compatibility
 - Complete nonchromate finish system from metal skin out

Aerospace's Oldest Exterior Coating Issue

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Paint Loss from Rivet Head (Rivet Rash)



Major Applications of Boegel EPII as Pretreatment

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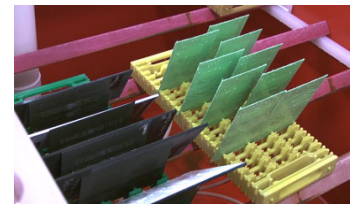


Non-Chromated Exterior Decorative Primer

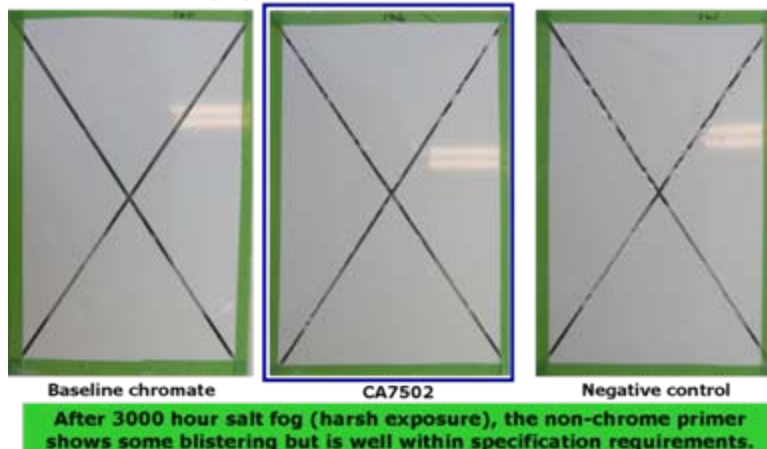
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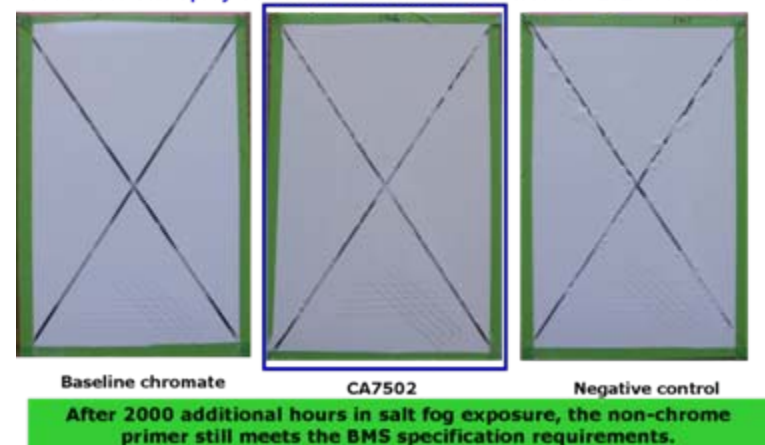
- **Screen Candidates/ Qualification testing**
 - **Requirements**
 - Good 3000 hour salt spray corrosion resistance
 - Acceptable 168 hour filiform corrosion resistance
 - Good rain erosion paint adhesion
 - **Beyond Requirements**
 - Good 5000 hour salt spray corrosion resistance
 - Acceptable 2000 hour filiform corrosion resistance



3000 Hour Salt Spray Corrosion Resistance Test Results – 2024-T3 Clad



5000 Hour Salt Spray Corrosion Resistance Test Results – 2024-T3 Clad



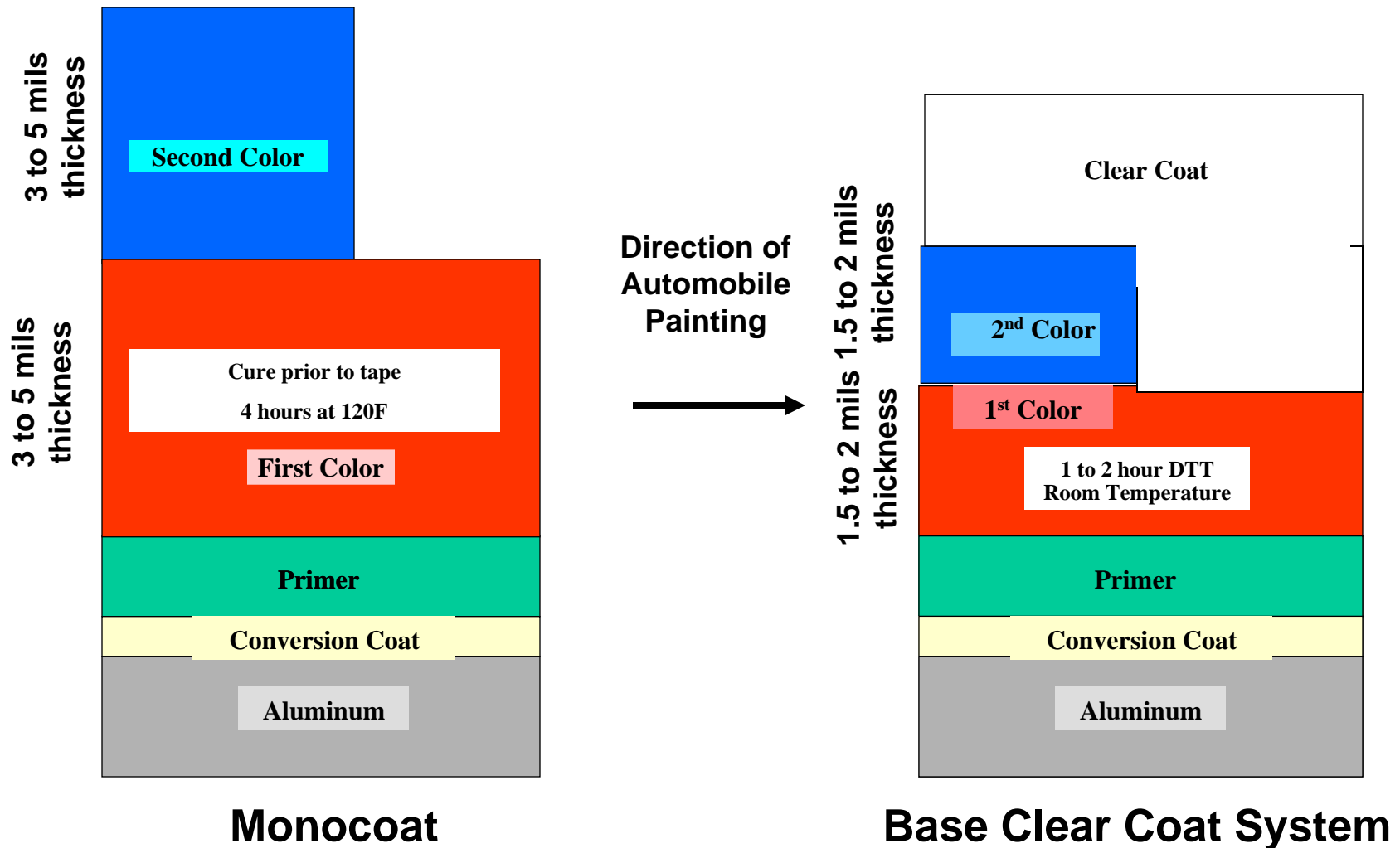
- **Driver: Performance (durability), production time**
- **Replaces decorative fuselage urethane topcoat**
 - Modeled after automotive system
 - System applies faster and thinner than conventional
 - Weight and flow time advantage
 - Better environmental durability
 - Solvent durability improving
 - Repair with conventional monocoats
- **Evolving clear coat to a matte finish will allow same technology on military vehicles**
 - Improved color, durability, cleanability over conventional

Base Coat Clear Coat (BCCC)

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What is Base Coat Clear Coat?



Conclusions

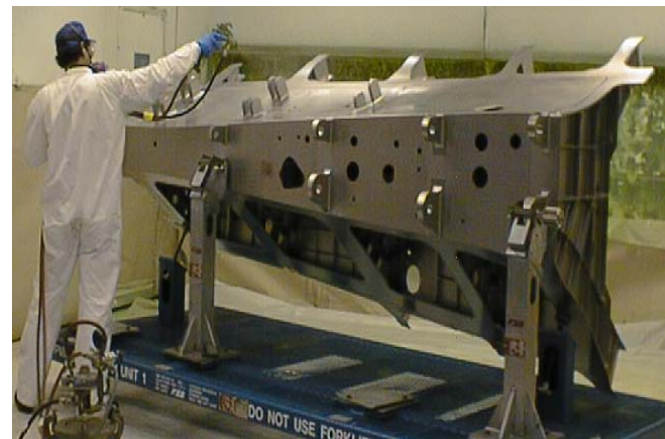
- **Listen hard to “customer”**
 - Understand whole problem and solve that problem
 - Demonstrate positive benefits to offset cost/uncertainty
- **Focus on solving problem for one part**
 - Targets development effort
 - Gains customer “pull”
 - General use specifications will evolve for good technologies
- **Be patient and persistent**
 - Understand product cycles
 - Be “performance ready” when product is in design phase
 - Be “manufacturing ready” when drawings are finalized

Questions?



Overview

- **Objective:** Summary of two processes used at Boeing that reduce or eliminate the use of chromates
- **Boric Sulfuric Acid Anodizing (BSAA)**
 - replaces chromic acid anodizing
- **Boegel conversion coatings**
 - Conversion coating based on sol-gel chemistry



Transition to Environmentally Compliant Materials

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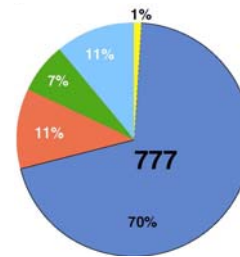
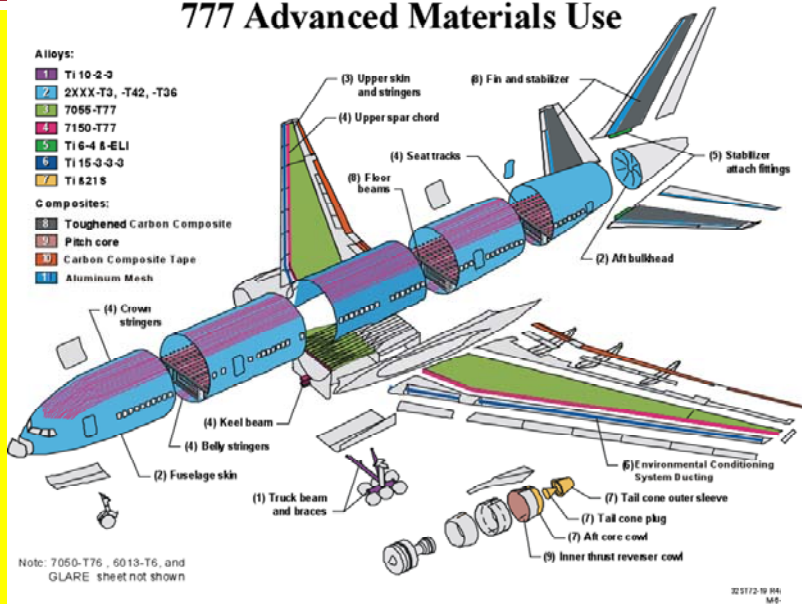
- **Elimination of chromates**
 - 70+ years of designing to the performance of chromates
 - All aircraft now in service are principally aluminum
 - Complex, poorly understood interactions between materials
 - The heritage systems are successful with chromates
 - The heritage systems must be successful with alternatives
- **VOC/HAZMAT Elimination**
 - Flexibility and durability of coatings change
 - Waterborne coatings are more porous than high solids
 - Affects moisture barrier and control
 - New runway deicers are corroding cadmium coatings
 - Fasteners and electrical connectors
 - Others?
- **New materials present new “opportunities”**

Advanced Materials Usage

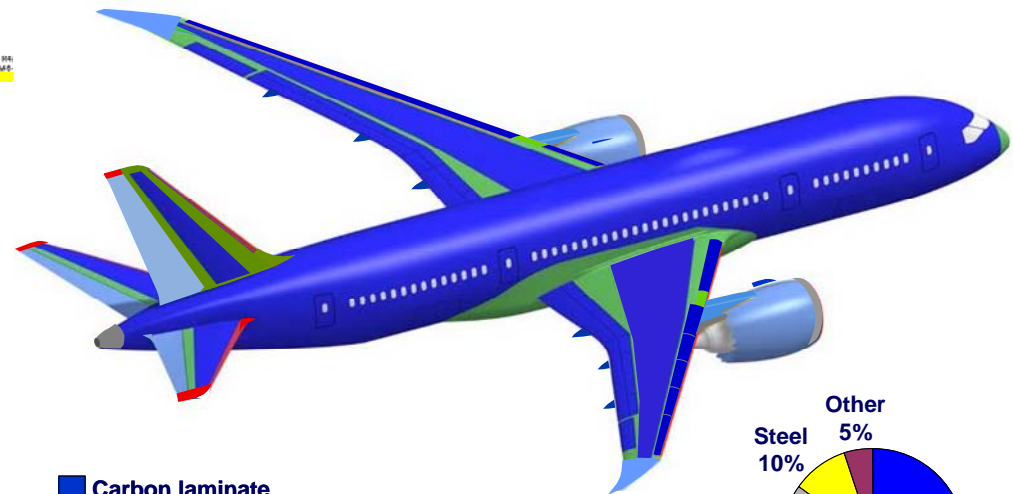
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777 Advanced Materials Use



Steel
Titanium
Composite
Misc.
Aluminum



787 Composite Primary Structure

Carbon laminate
Carbon sandwich
Other composites
Aluminum
Titanium

